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the seventh left pixel in Fig. 19 corresponding to the third shutter time/v since the time of shutter opening and to the foreground component of the eighth left pixel in Fig. 19 corresponding to the fourth shutter time/v since the time of shutter opening.

Since the object corresponding to the foreground is a rigid body and may be assumed to be moving at an equal speed, with the movement quantity v being 4, the first foreground component F02/v of the sixth left pixel in Fig. 19, with the first shutter time/v since the time of shutter opening, is equal to the second foreground component of the seventh left pixel in Fig. 19 corresponding to the second shutter time/v since the time of shutter opening. Similarly, the foreground component F02/v is equal to the foreground component of the eighth left pixel in Fig. 19 corresponding to the third shutter time/v since the time of shutter opening.

Since the object corresponding to the foreground is a rigid body and may be assumed to be moving at an equal speed, with the movement quantity v being 4, the first foreground component F03/v of the seventh left pixel in Fig. 19, with the first shutter time/v since the time of shutter opening, is equal to the second foreground component of the eighth left pixel in Fig. 19 corresponding to the second shutter time/v since the time of shutter opening.

Although the number of times of the virtual splitting is four in the description with respect to Figs. 17 to 19, the number of times of the virtual splitting corresponds to the movement quantity v. The movement quantity v generally corresponds to the movement speed of the object corresponding to the foreground. For example, if the

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object corresponding to the foreground is moving so as to be displayed four pixels rightwards in a frame next to a previous reference frame, the movement quantity v is 4. The number of times of the virtual splitting is set to 4 in association with the movement quantity v. Similarly, if the object corresponding to the foreground is moving so as to be displayed six pixels rightwards in a frame next to a previous reference frame, the movement quantity v is 6, with the number of times of the virtual splitting being six.

Figs.20 and 21 show the relation between the foreground area, background area, and the mixed area, comprised of the covered background area and the uncovered background area, on one hand, and the foreground and background components corresponding to the split shutter time, on the other hand, as described above.

Fig.20 shows an example of extraction of pixels of the foreground area, background area and the mixed area as extracted from a picture corresponding to an object moving before a still background. In the embodiment shown in Fig.20, an object corresponding to the foreground is moving horizontally with respect to the picture.

The frame #n+1 is a frame next to the frame #n, with the frame #n+2 being a frame next to the frame #n+1.

Fig.21 diagrammatically shows a model obtained on extracting pixels of the foreground area, background area and the mixed area, extracted in turn from one of the frames #n to #n+2, with the movement quantity v being 4, and on expanding the

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pixel values of the extracted pixels along the time axis direction.

Since the object corresponding to the foreground is moved, the pixel values of the foreground area are constituted by four different foreground components corresponding to the period of the shutter time/v. For example, the leftmost one of pixels of the foreground area shown in Fig.21 are F01/v, F02/v, F03/v and F04/v. That is the pixels of the foreground area contain are corrupted with motion blurring.

Since the object corresponding to the background is at a standstill, the light corresponding to the background input to the sensor 11 during the time corresponding to the shutter time is not changed. In this case, the pixel values of the background are free of the motion blurring.

The pixel values or the pixels belonging to the mixed area composed of the covered background area or the uncovered background area are comprised of the foreground and background components.

A model comprised of neighboring pixels in a row in plural frames, in which the pixel values of pixels lying at the same position on a frame are developed in the time axis direction, with the picture corresponding to an object being moved, is explained. For example, if the picture corresponding to the object is moving horizontally with respect to the picture, the pixels arrayed on the same row on the picture may be selected as the pixels in a row in a picture.

Fig.22 diagrammatically shows a model obtained on temporally expanding the pixel values of pixels arrayed in a row of each of three frames of a picture of a

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photographed object corresponding to a still background, with the developed pixels being at the same positions on the respective frames. The frame #n is the frame next to the frame #n-1, with the frame #n+1 being the frame next to the frame #n. The remaining frames are termed in similar manner.

The pixel values of B01 to B12 shown in Fig.22 are those of pixels corresponding to the object of the still background. Since the objet corresponding to the background is at a standstill, the pixel values of the corresponding pixels in the frames #n·1 ti frame n+1 are not changed. For example, the pixel in the frame #n and the pixel in the frame #n+1, corresponding to the positions of the pixels having pixel values of B05 in the frame #n·1, are of pixel values of B05.

Fig.23 shows pixel values of neighboring pixels in a row in each of three frames of a photographed picture of an object corresponding to the foreground moving rightwards in Fig.23, along with the object corresponding to the still background, with the pixel values being shown developed along the time axis direction. The model shown in Fig.23 includes a covered background area.

In Fig.23, the object corresponding to the foreground is a rigid body and may be assumed to be moving at a constant speed, with the foreground picture being moved so that the foreground picture will be displayed four pixels rightwards in the next frame. So, the movement quantity v of the foreground is 4, with the number of times of the virtual splitting being 4.

For example, the foreground component of the leftmost pixel of the frame #n·1

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in Fig.23, with the first shutter time /v since the opening of the shutter, is F12/v, whilst the foreground component of the second left pixel, with the second shutter time /v since the opening of the shutter, is also F12v. The foreground component of the third left pixel in Fig.23, with the third shutter time/v since the opening of the shutter, and the foreground component of the fourth left pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, are each F12/v.

For example, the foreground component of the leftmost pixel of the frame #n·1 in Fig.23, with the second shutter time /v since the opening of the shutter, is F11/v, whilst the foreground component of the second left pixel, with the third shutter time /v since the opening of the shutter, is also F11v. The foreground component of the third left pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, is F11/v.

The foreground component of the leftmost pixel of the frame #n·1 in Fig.23, with the third shutter time /v since the opening of the shutter, is F10/v, whilst the foreground component of the second left pixel, with the fourth shutter time /v since the opening of the shutter, is also F10v. The foreground component of the leftmost pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, is F09/v.

Since the object corresponding to the background is at a standstill, the background component of the second left pixel of the frame #n·1 in Fig.23, with the first shutter time/v as from the shutter opening time, is B01/v. The background component of the third left pixel of the frame #n·1 in Fig.23, with the first and second

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shutter time/v as from the shutter opening time, is B02/v, while the background component of the fourth left pixel of the frame #n·1 in Fig.23, with the first to third shutter time/v as from the shutter opening time, is B03/v.

In the frame #n·1 in Fig.23, the leftmost pixel belongs to the foreground area, while the second to fourth left pixels belong to the mixed area which is the covered background area.

The fifth to twelfth left pixels of the frame #n·1 in Fig.23 belong to the background area, with the corresponding pixel values being B04 to B11, respectively.

The first to fifth pixels of the frame #n·1 in Fig.23 belong to the background area. The foreground component in the foreground area of the frame #n, with the shutter time/v, is one of F05v to F12/v.

Since the object corresponding to the foreground is a rigid body and may be assumed to be moving at a constant speed, with the foreground picture being moved so that the foreground picture will be displayed four pixels rightwards in the next frame, the foreground component of the fifth left pixel of the frame #n·in Fig.23, with the first shutter time /v since the opening of the shutter, is F12/v, whilst the foreground component of the sixth left pixel, with the second shutter time /v since the opening of the shutter, is also F12v. The foreground component of the seventh left pixel in Fig.23, with the third shutter time/v since the opening of the shutter, and the foreground component of the eighth left pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, are each F12/v.

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The foreground component of the fifth left pixel of the frame #n in Fig.23, with the second shutter time /v since the opening of the shutter, is F11/v, whilst the foreground component of the sixth left pixel, with the third shutter time /v since the opening of the shutter, is also F11v. The foreground component of the seventh left pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, is F11/v.

The foreground component of the fifth left pixel of the frame #n in Fig.23, with the third shutter time /v since the opening of the shutter, is F10/v, whilst the foreground component of the sixth left pixel, with the fourth shutter time /v since the opening of the shutter, is also F10v. The foreground component of the fifth left pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, is F09/v.

Since the object corresponding to the background is at a standstill, the background component of the sixth left pixel of the frame #n in Fig.23, with the first shutter time/v as from the shutter opening time, is B05/v. The background component of the seventh left pixel of the frame #n in Fig.23, with the first and second shutter time/v as from the shutter opening time, is B06/v, while the background component of the eighth left pixel of the frame #n in Fig.23, with the first to third shutter time/v as from the shutter opening time, is B07/v.

In the frame #n·1 in Fig.23, the first to ninth left pixels belong to the foreground area, while the sixth to eighth left pixels belong to the mixed area which is the covered background area.

The first to ninth to twelfth left pixels of the frame #n+1 in Fig.23 belong to the

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foreground area, with the pixel values being B08 to B11, respectively.

The first to ninth pixels of the frame #n+1 in Fig.23 belong to the foreground area. The foreground component in the foreground area of the frame #n+1, with the shutter time/v, is one of F01v to F12/v.

Since the object corresponding to the foreground is a rigid body and may be assumed to be moving at a constant speed, with the foreground picture being moved so that the foreground picture will be displayed four pixels rightwards in the next frame, the foreground component of the ninth left pixel of the frame #n+1 in Fig.23, with the first shutter time /v since the opening of the shutter, is F12/v, whilst the foreground component of the tenth left pixel, with the second shutter time /v since the opening of the shutter, is also F12v. The foreground component of the eleventh left pixel in Fig.23, with the third shutter time/v since the opening of the shutter, and the foreground component of the twelfth left pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, are each F12/v.

The foreground component of the ninth left pixel of the frame #n+1 in Fig.23, with the second shutter time /v since the opening of the shutter, is F11/v, whilst the foreground component of the tenth left pixel, with the third shutter time /v since the opening of the shutter, is also F11v. The foreground component of the eleventh left pixel in Fig.23, with the fourth shutter time/v since the opening of the shutter, is F11/v.

The foreground component of the ninth left pixel of the frame #n+1 in Fig.23, with the third shutter time /v since the opening of the shutter, is F10/v, whilst the

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foreground component of the tenth left pixel, with the fourth shutter time /v since the opening of the shutter, is also F10v. The foreground component of the ninth left pixel of the frame #n+1 in Fig.23, with the fourth shutter time/v since the opening of the shutter, is F09/v.

Since the object corresponding to the background is at a standstill, the background component of the tenth left pixel of the frame #n+1 in Fig.23, with the first shutter time/v as from the shutter opening time, is B09/v. The background component of the eleventh left pixel of the frame #n+1 in Fig.23, with the first and second shutter time/v as from the shutter opening time, is B10/v, while the background component of the twelfth left pixel of the frame #n+1 in Fig.23, with the first to third shutter time/v as from the shutter opening time, is B11/v.

In the frame #n+1 in Fig.23, the tenth to twelfth left pixels correspond to the mixed area which is the covered background area.

Fig.24 diagrammatically shows a picture obtained on extracting the foreground component from the pixel values shown in Fig.23.

Fig.25 shows neighboring pixels in a row of each of three frames of a photographed picture of the foreground corresponding to an object moving rightwards in the drawing, along with the still background. In Fig.25, there is also shown the uncovered background area.

In Fig.25, the object corresponding to the foreground is a rigid body and may be assumed to be moving at a constant speed, with the foreground picture being moved

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so that the foreground picture will be displayed four pixels rightwards in the next frame. So, the movement quantity v of the foreground is 4.

For example, the foreground component of the leftmost pixel of the frame #n·1 in Fig.25, with the first shutter time /v since the opening of the shutter, is F13/v, whilst the foreground component of the second left pixel, with the second shutter time /v since the opening of the shutter, is also F13v. The foreground component of the third left pixel in Fig.23, with the second shutter time/v since the opening of the shutter, and the foreground component of the fourth left pixel in Fig.25, with the fourth shutter time/v since the opening of the shutter, are each F13/v.

For example, the foreground component of the second left pixel of the frame #n·1 in Fig.23, with the first shutter time /v since the opening of the shutter, is F14/v, whilst the foreground component of the third left pixel, with the second shutter time /v since the opening of the shutter, is also F14v. The foreground component of the third left pixel in Fig.25, with the first shutter time/v since the opening of the shutter, is F15/v.

Since the object corresponding to the background is at a standstill, the background component of the leftmost pixel of the frame #n·1 in Fig.25, with the second to fourth shutter time/v as from the shutter opening time, is B01/v. The background component of the second left pixel of the frame #n·1 in Fig.25, with the third and fourth shutter time/v as from the shutter opening time, is B26/v, while the background component of the third left pixel of the frame #n·1 in Fig.25, with the

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fourth shutter time/v as from the shutter opening time, is B27/v.

In the frame #n·1 in Fig.25, the first to third left pixel belongs to the mixed area which is the covered background area.

The fourth to twelfth left pixels of the frame #n·1 in Fig.25 belong to the foreground area, with the foreground component of the foreground of the frame being one of F13v to F24v.

The first to fourth left pixels of the frame #n in Fig.25 belong to the background area, with the pixel values being B25 to B28, respectively.

Since the object corresponding to the foreground is a rigid body and may be assumed to be moving at a constant speed, with the foreground picture being moved so that the foreground picture will be displayed four pixels rightwards in the next frame, the foreground component of the fifth left pixel of the frame #n in Fig.23, with the first shutter time /v since the opening of the shutter, is F13/v, whilst the foreground component of the sixth left pixel, with the second shutter time /v since the opening of the shutter, is also F13v. The foreground component of the seventh left pixel in Fig.25, with the third shutter time/v since the opening of the shutter, and the foreground component of the eighth left pixel in Fig.25, with the fourth shutter time/v since the opening of the shutter, are each F13/v.

The foreground component of the sixth left pixel of the frame #n in Fig.23, with the first shutter time /v since the opening of the shutter, is F14/v, whilst the foreground component of the seventh left pixel, with the second shutter time /v since the opening

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of the shutter, is also F14v. The foreground component of the eighth left pixel in Fig.25, with the first shutter time/v since the opening of the shutter, is F15/v.

Since the object corresponding to the background is at a standstill, the background component of the fifth left pixel of the frame #n in Fig.25, with the second to fourth shutter time/v as from the shutter opening time, is B29/v. The background component of the sixth left pixel of the frame #n in Fig.25, with the third and fourth shutter time/v as from the shutter opening time, is B30/v, while the background component of the seventh left pixel of the frame #n in Fig.23, with the fourth shutter time/v as from the shutter opening time, is B31/v.

In the frame #n in Fig.25, the first to ninth left pixels belong to the foreground area, while the fifth to seventh left pixels belong to the mixed area which is the covered background area.

The eighth to twelfth left pixels of the frame #n+1 in Fig.25 belong to the foreground area, with the pixel values being B25 to B32, respectively.

The first to eighth pixels of the frame #n+1 in Fig.25 belong to the background area, with the pixel values being B25 to B32, respectively.

Since the object corresponding to the foreground is a rigid body and may be assumed to be moving at a constant speed, with the foreground picture being moved so that the foreground picture will be displayed four pixels rightwards in the next frame, the foreground component of the ninth left pixel of the frame #n+1 in Fig.25, with the first shutter time /v since the opening of the shutter, is F13/v, whilst the

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foreground component of the tenth left pixel, with the second shutter time /v since the opening of the shutter, is also F13v. The foreground component of the eleventh left pixel in Fig.25, with the third shutter time/v since the opening of the shutter, and the foreground component of the twelfth left pixel in Fig.25, with the fourth shutter time/v since the opening of the shutter, are each F13/v.

The foreground component of the tenth left pixel of the frame #n+1 in Fig.25, with the first shutter time /v since the opening of the shutter, is F14/v, whilst the foreground component of the eleventh left pixel, with the second shutter time /v since the opening of the shutter, is also F14v. The foreground component of the twelfth left pixel in Fig.25, with the first shutter time/v since the opening of the shutter, is F15/v.

Since the object corresponding to the background is at a standstill, the background component of the ninth left pixel of the frame #n+1 in Fig.25, with the second to fourth shutter time/v as from the shutter opening time, is B33/v. The background component of the tenth left pixel of the frame #n+1 in Fig.25, with the third and fourth shutter time/v as from the shutter opening time, is B34/v, while the background component of the eleventh left pixel of the frame #n+1 in Fig.25, with the fourth shutter time/v as from the shutter opening time, is B35/v.

In the frame #n+1 in Fig.25, the ninth to eleventh left pixels correspond to the mixed area which is the covered background area.

In Fig.25, the twelfth left pixel of the frame #n+1 belong to the foreground area. The foreground component with the shutter time/v in the foreground area of frame

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#n+1 is one of F13v to F16v.

Fig.26 diagrammatically shows a picture obtained on extracting the foreground component from the pixel values shown in Fig.25.

Reverting to Fig.10, the area specifying unit 103 associates a flag, indicating that a given picture belong to the foreground area, a background area, a covered background area or an uncovered background area, from pixel to pixel, using pixel value of plural frames, and routes the resulting areal information to the mixing ratio calculating unit 104 and to the motion blurring adjustment unit 106.

Based on the pixel values of plural frames and the areal information, the mixing ratio calculating unit 104 computes the mixing ratio α for each of the pixels contained in the mixed area, and sends the computed mixing ratio α to the foreground/background separating unit 105.

Based on the pixel values of the plural frames, areal information and the mixing ratio α, the foreground/background separating unit 105 extracts the foreground component picture made up only of the foreground component to send the extracted component picture to the motion blurring adjustment unit 106.

Based on the foreground component picture sent from the foreground/background separating unit 105, the motion vector sent from the motion detection unit 102 and on the areal information sent from the area specifying unit 103, the motion blurring adjustment unit 106 adjusts the quantity of the motion blurring contained in the foreground component picture to output the foreground component

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picture adjusted for the motion blurring.

Referring to the flowchart of Fig.27, the processing for adjusting the motion blurring caused by the signal processor 12 is explained. At step S101, the area specifying unit 103 executes the area specifying processing for generating the areal information indicating to which of the foreground area, background area, covered background area or the uncovered background area belong the pixels of the input picture, from one pixel of the input picture to another. The area specifying processing will be explained subsequently by referring to the flowchart of Fig.36. The area specifying unit 103 sends the generated area information to the mixing ratio calculating unit 104.

Meanwhile, the area specifying unit 103 at step S101 may generate the areal information indicating to which of the foreground area, background area or the mixed area belong the pixels of the input picture, from one pixel of the input picture to another, based on the input picture. In this case, no distinction is made between the covered background area and the uncovered background area. In this case, the foreground/background separating unit 105 and the motion blurring adjustment unit 106 decide whether the mixed area is the covered background area or the uncovered background area, based on the direction of the motion vector. For example, if the foreground area, mixed area and the background area are arrayed sequentially in association with the direction of the motion vector, the mixed area is verified to be the covered background area, whereas, if the background area, mixed area and the

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foreground area are arrayed sequentially in association with the direction of the motion vector, the mixed area is verified to be the uncovered background area.

At step S102, the mixing ratio calculating unit 104 calculates the mixing ratio α, from one pixel contained in the mixing area to another, based on the input picture and the area information The processing for computing the mixing ratio will be explained in detail subsequently by referring to the flowchart of Fig.46. The mixing ratio calculating unit 104 sends the computed mixing ratio α to the foreground/background separating unit 105.

At step S103, the foreground/background separating unit 105 extracts the foreground component from the input picture, based on the motion vector and the areal information, to send the extracted component to the motion blurring adjustment unit 106 as the foreground component picture.

At step S104, the motion blurring adjustment unit 106 generates a processing unit for indicating a position on the picture of pixels arrayed consecutively in the movement direction of each of the uncovered background area, foreground area and the covered background area, based on the motion vector and on the area information, to adjust the quantity of the motion blurring contained in the foreground component corresponding to the processing unit. The processing for adjusting the quality of the motion blurring will be explained subsequently by referring to the flowchart of Fig.63.

At step S105, the signal processor 12 verifies whether or not the processing has been finished for the entire picture. If the signal processor 12 has verified that the

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processing has not been finished fort the entire picture, it proceeds to step S104 to repeat the processing for adjusting the quantity of the motion blurring for the foreground component corresponding to the processing unit.

If, at step S106, it is verified that the processing has been finished for the entire picture, the processing is terminated.

In this manner, the signal processor 12 is able to separate the foreground and the background from each other to adjust the quantity of the motion blurring contained in the foreground. That is, the signal processor 12 is able to adjust the amount of motion blurring contained in sample data as pixel value of the foreground pixel.

In the following, illustrative structures of the area specifying unit 103, mixing ratio calculating unit 104, foreground/background separating unit 105 and the motion blurring adjustment unit 106 are hereinafter explained.

Fig.28 is a block diagram showing an illustrative structure of the area specifying unit 103. A frame memory 121 stores an input picture on the frame basis. When a frame being processed is a frame #n, the frame memory 121 stores a frame #n·2, as a frame two frames before the frame #n, a frame #n·1, as a frame one frame before the frame #n, a frame #n+1, as a frame one frame after the frame #n, and a frame #n+2, as a frame two frames after the frame #n.

A still/movement discriminating unit 122-1 reads out a pixel value of a pixel of the frame #n+2 lying at the same position as the position on the picture of the pixel of the frame #n being area-specified, and a pixel value of a pixel of the frame #n+1

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lying at the same position as the position on the picture of the pixel of the frame #n being area-specified, from the frame memory 121, to calculate an absolute value of the difference of the read-our pixel values. The still/movement discriminating unit 122-1 verifies whether or not the absolute value of the difference between the pixel value of the frame #n+2 and the frame #n+1 is larger than a predetermined threshold value Th. If it is verified that the absolute value of the difference is larger than the threshold value Th, the still/movement discriminating unit 122-1 routes a still/movement decision specifying the movement decision to an area decision unit 123-1. If it is verified that the absolute value o the difference between the pixel value of the frame #n+2 nd the pixel value of the frame #n+1 is not larger than the threshold value Th, the still/movement discriminating unit 122-1 routes a still/movement decision specifying the still decision to an area decision unit 123-1.

A still/movement discriminating unit 122-2 reads out a pixel value of a pixel of the frame #n+1 lying at the same position as the position on the picture of the pixel of the frame #n being area-specified, and a pixel value of a pixel of the frame #n+1 lying at the same position as the position on the picture of the pixel of the frame #n being area-specified, from the frame memory 121, to calculate an absolute value of the difference of the read-our pixel values. The still/movement discriminating unit 122-2 verifies whether or not the absolute value of the difference between the pixel value of the frame #n+1 and the frame #n is larger than a predetermined threshold value Th. If it is verified that the absolute value of the difference between the is larger than the

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threshold value Th, the still/movement discriminating unit 122-1 routes a still/movement decision specifying the movement decision to an area decision unit 123-1and to an area decision unit 123-2. If it is verified that the absolute value of the difference between the pixel value of the pixel of the frame #n+1 and that of the pixel of the frame #n is not larger than the threshold value Th, the still/movement discriminating unit 122-1 routes a still/movement decision specifying the still decision to an area decision unit 123-1 and to an area decision unit 123-2.

A still/movement discriminating unit 122-3 reads out a pixel value of a pixel of the frame #n lying at the same position as the position on the picture of the pixel of the frame #n being area-specified, and a pixel value of a pixel of the frame #n·1 lying at the same position as the position on the picture of the pixel of the frame #n being area-specified, from the frame memory 121, to calculate an absolute value of the difference of the read-our pixel values. The still/movement discriminating unit 122-3 verifies whether or not the absolute value of the difference between the pixel value of the frame #n and the frame #n·1 is larger than a predetermined threshold value Th. If it is verified that the absolute value of the difference between the pixel values is larger than the threshold value Th, the still/movement discriminating unit 122-3 routes a still/movement decision specifying the movement decision to an area decision unit 123-1and to an area decision unit 123-3. If it is verified that the absolute value of the difference between the pixel value of the pixel of the frame #n and that of the pixel of the frame #n·1 is not larger than the threshold value Th, the still/movement

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discriminating unit 122-3 routes a still/movement decision specifying the still decision to an area decision unit 123-2 and to an area decision unit 123-3.

A still/movement discriminating unit 122-4 reads out the pixel value of the pixel of the frame #n-1 lying at the same position as the position on the picture of the pixel of the frame #-n being area-specified, and the pixel value of the pixel of the frame #n-2 lying at the same position on the picture of the pixel of the frame #n being area-specified, to calculate the absolute value of the difference of the pixel values. The still/movement discriminating unit 122-4 verifies whether or not the absolute value of the difference of the pixel value of the frame #n-1 and the pixel value of the frame #n-2 is larger than the predetermined threshold value Th. If the absolute value of the difference between the pixel value of the frame #n-1 and the pixel value of the frame #n-2 is verified to be larger than the threshold value Th, a still/movement decision indicating the decision for movement is routed to the area decision unit 123-3. If it is verified that the absolute value of the difference between the pixel value of the frame #n-1 and the pixel value of the frame #n-2 is not larger than the threshold value Th, the still/movement discriminating unit 122-4 routes a still/movement decision indicating the still decision to the area decision unit 123-3.

If the still/movement decision routed from the still/movement discriminating unit 122-1 indicates still and the still/movement decision routed from the still/movement discriminating unit 122-2 indicates movement, the area decision unit 123-1 decides that the pixel on the frame #n being area-specified belongs to the

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uncovered background area and sets "1" in an uncovered background area decision flag associated with the pixel being area-specified for indicating that the pixel belongs to the uncovered background area.

If the still/movement decision routed from the still/movement discriminating unit 122-1 indicates movement and the still/movement decision routed from the still/movement discriminating unit 122-2 indicates still, the area decision unit 123-1 decides that the pixel on the frame #n being area-specified does not belong to the uncovered background area and sets "0" in an uncovered background area decision flag associated with the pixel being area-specified for indicating that the pixel does not belong to the uncovered background area.

The area decision unit 123-1 routes the uncovered background area decision flag, having "1" or "0" set in this manner, to a decision flag storage memory 124.

If the still/movement decision routed from the still/movement discriminating unit 122-2 indicates still and the still/movement decision routed from the still/movement discriminating unit 122-3 indicates still, the area decision unit 123-2 decides that the pixel on the frame #n being area-specified belongs to the still area and sets "1" in a still area decision flag associated with the pixel being area-specified for indicating that the pixel belongs to the uncovered background area.

If the still/movement decision routed from the still/movement discriminating unit 122-2 indicates movement or the still/movement decision routed from the still/movement discriminating unit 122-3 indicates movement, the area decision unit

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123-2 decides that the pixel on the frame #n being area-specified does not belong to the still area and sets "0" in a still area decision flag associated with the pixel being area-specified for indicating that the pixel does not belong to the still area.

The area decision unit 123-2 routes the still area decision flag, thus having "1" or "0" set therein, to the decision flag storage memory 124.

If the still/movement decision routed from the still/movement discriminating unit 122-2 indicates movement and the still/movement decision routed from the still/movement discriminating unit 122-3 indicates movement, the area decision unit 123-2 decides that the pixel on the frame #n being area-specified belongs to the movement area and sets "1" in a movement area decision flag associated with the pixel being area-specified for indicating that the pixel belongs to the movement area.

If the still/movement decision routed from the still/movement discriminating unit 122-2 indicates still or the still/movement decision routed from the still/movement discriminating unit 122-3 indicates still, the area decision unit 123-2 decides that the pixel on the frame #n being area-specified does not belong to the movement area and sets "0" in a movement area decision flag associated with the pixel being area-specified for indicating that the pixel does not belong to the movement area.

The area decision unit 123-2 routes the movement area decision flag, thus having "1" or "0" set therein, to the decision flag storage memory 124.

If the still/movement decision routed from the still/movement discriminating unit 122-3 indicates movement and the still/movement decision routed from the

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still/movement discriminating unit 122-4 indicates still, the area decision unit 123-3

decides that the pixel on the frame #n being area-specified belongs to the uncovered

background area and sets "1" in a covered background area decision flag associated

with the pixel being area-specified for indicating that the pixel belongs to the covered

background area.

If the still/movement decision routed from the still/movement discriminating

unit 122-3 indicates still or the still/movement decision routed from the still/movement

discriminating unit 122-4 indicates movement, the area decision unit 123-3 decides

that the pixel on the frame #n being area-specified does not belong to the covered

background area and sets "0" in a covered background area decision flag associated

with the pixel being area-specified for indicating that the pixel does not belong to the

covered background area.

The area decision unit 123-3 routes the covered background area decision flag,

thus having "1" or "0" set therein, to the covered background area decision flag storage

memory 124.

The decision flag storage memory 124 stores the uncovered background area

decision flag, sent from the area decision unit 123-1, the still area decision flag, sent

from the area decision unit 123-2, the movement area decision flag, sent from the area

decision unit 123-2, and the uncovered background area decision flag, sent from the

area decision unit 123-3.

The decision flag storage memory 124 sends the uncovered background area

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decision flag, still area decision flag, movement area decision flag and the covered background area decision flag to a synthesis unit 125. Based on the uncovered background area decision flag, still area decision flag, movement area decision flag and the covered background area decision flag, supplied from the decision flag storage memory 124, the synthesis unit generates the area information indicating to which of the uncovered background area, still area, movement area and the covered background area belong the respective pixels, and routes the information so generated to a decision flag storage frame memory 126.

The decision flag storage frame memory 126 stores the area information, supplied from the synthesis unit 125, while outputting the area information stored therein.

Referring to Figs.29 to 33, a typical processing by the area specifying unit 103 is explained.

When an object corresponding to the foreground is moving, the position of the picture corresponding to the object on the picture screen is changed from frame to frame. Referring to Fig.29, a picture corresponding to an object at a position $Yn(x, y)$ in a frame #n is positioned at $Yn+1(x,y)$ at the next frame #n+1.

Fig.30 diagrammatically shows a model of pixel values of a row of pixels neighboring to one another along the moving direction of the picture corresponding to the foreground. For example, if the movement direction of the picture corresponding to the foreground is horizontal relative to the picture screen, the

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diagrammatic view of Fig.30 shows a model in which pixel values of pixels neighboring to one another on one line are developed in the time axis direction.

In Fig.30, the line in the frame #n is the same as one in the frame #n+1.

The components of the foreground corresponding to the object contained in the second to the thirteenth pixels as counted from left in the frame #n are included in the sixth to seventeenth pixels as counted from the left of the frame #n+1.

The pixels belonging to the covered background area in the frame #n are the eleventh to thirteenth pixels as counted from left, whilst the pixels belonging to the uncovered background area are the second to fourth pixels as counted from left. The pixels belonging to the covered background area in the frame #n+1 are the fifteenth to seventeenth pixels as counted from left, whilst the pixels belonging to the uncovered background area are the sixth to eighth pixels as counted from left.

In the example shown in Fig.30, since the foreground component in the frame #n are moved by four pixels in the frame #n+1, the movement quantity v is 4. The number of times of the virtual splitting corresponds to the movement quantity and is equal to 4.

The change in the pixel values of pixels belonging to the mixed area ahead and at back of the frame being considered is explained.

In the frame #n shown in Fig.31, in which the background is still and the movement quantity of the foreground v is 4, pixels belonging to the covered background area are fifteenth to seventeenth pixels from left. Since the movement

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quantity v is 4, the fifteenth to seventeenth pixels from left in the directly previous frame #n·1 contain only the background components and belong to the background. The fifteenth to seventeenth pixels from left in the further previous frame #n·2 contain only the background components and belong to the background area.

Since the object corresponding to the background is still, the pixel value of the fifteenth pixel from the left of the frame #n·1 is not changed from the pixel value of the fifteenth pixel from the left of the frame #n·2. Similarly, the pixel value of the sixteenth pixel from the left of the frame #n·1 is not changed from the pixel value of the sixteenth pixel from the left of the frame #n·2, whilst the pixel value of the seventeenth pixel from the left of the frame #n·1 is not changed from the pixel value of the seventeenth pixel from the left of the frame #n·2.

That is, the pixels of the frame #n·1 and the frame #n·2 corresponding to the pixels belonging to the covered background area in the frame #n are comprised only of the background components and are not changed, so that the absolute value of the difference is substantially 0. So, the still/movement decision on the pixels of the frame #n·1 and frame #n·2 corresponding to the mixed area in the frame #n is made as being still by the still/moving discriminating unit 122-4.

Since the pixels belonging to the covered background area in the frame #n contain the foreground components, the corresponding pixel values differ from those in which the pixels are comprised only of background components in the frame #n·1. Therefore, the pixels belonging to the mixed area in the frame #n and the

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corresponding pixels of the frame #n·1 are verified to be moving pixels by the still/moving discriminating unit 122-3.

When fed with the result of still/movement decision indicating the movement from the still/moving discriminating unit 122-3 and with the result of still/movement decision indicating the still from the still/moving discriminating unit 122-4, the area decision unit 123-3 decides that the pixel in question belongs to the covered background area.

The pixels contained in the uncovered background area in the frame #n in which the background is still and the movement quantity v of the foreground is 4 are second to fourth pixels as counted from left. Since the movement quantity v is 4, the second to fourth pixels from left in the next frame #n+1 contain only the background components and belong to the background area. In the second next frame #n+2, the second to fourth pixels from left contain only the background components and belong to the background area.

Since the object corresponding to the background is still, the pixel value of the second pixel from left of the frame #n+2 is not changed from the pixel value of the second pixel from left of the frame #n+1. Similarly, the pixel value of the second pixel from left of the frame #n+2 is not changed from the pixel value of the second pixel from left of the frame #n+1, whilst the pixel value of the third pixel from left of the frame #n+2 is not changed from the pixel value of the fourth pixel from left of the frame #n+1.

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That is, the pixels of the frame #n+1 and frame #n+2 corresponding to the pixels belonging to the uncovered background area in the frame #n are composed only of background components and are not changed in the pixel values. So, the absolute value of the difference is approximately zero. Therefore, the pixels of the frame #n+1 and frame #n+2 corresponding to the pixels belonging to the mixed area in the frame #n are decided by the still/moving discriminating unit 122-1 to be still pixels.

The pixels belonging to the uncovered background area in the frame #n contain the foreground components and hence differ in pixel values from the pixels in the frame #n+1 composed only of the background components. So, the pixels belonging to the mixed area in the frame #n and those of the corresponding frame #n·1 are decided by the still/moving discriminating unit 122-2 to be moving pixels.

The area decision unit 123-1 is fed in this manner with the result indicating movement from the still/moving discriminating unit 122-2. If fed with the result indicating still from the still/moving discriminating unit 122-1, the area decision unit 123-1 decides that the corresponding pixel belongs to the uncovered background area.

Fig.33 shows decision conditions of the area specifying unit 103 in the frame #n. When the pixel of the frame #n·2 at the same position as the position on the picture of the pixel of the frame #n being verified and the pixel of the frame #n·1 at the same position as the position on the picture of the pixel of the frame #n being verified, are decided to be still, whilst the pixel of the frame #n·1 at the same position as the position on the picture of the pixel of the frame #n being verified and the pixel

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of the frame #n are decided to be moving, the area specifying unit 103 decides that the pixel of the frame #n being verified belongs to the covered background area.

When the pixel of the frame #n·1 at the same position as the position on the picture of the pixel of the frame #n being verified and the pixel of the frame #n are decided to be still, whilst the pixel of the frame #n and the pixel of the frame #n+1 at the same position as the position on the picture of the pixel of the frame #n being verified are decided to be still, the area specifying unit 103 decides that the pixel of the frame #n being verified belongs to the still area.

When the pixel of the frame #n·1 at the same position as the position on the picture of the pixel of the frame #n being verified and the pixel of the frame #n are decided to be moving, whilst the pixel of the frame #n and the pixel of the frame #n+1 at the same position as the position on the picture of the pixel of the frame #n being verified are decided to be still, the area specifying unit 103 decides that the pixel of the frame #n being verified belongs to the moving area.

When the pixel of the frame #n and the pixel of the frame #n+1 at the same position as the position on the picture of the pixel of the frame #n being verified are decided to be moving and when the pixel of the frame #n+1 at the same position as the position on the picture of the pixel of the frame #n being verified and the pixel of the frame #n+1 at the same position as the position on the picture of the pixel of the frame #n being verified and the pixel of the frame #n+2 at the same position as the position on the picture of the pixel of the frame #n being verified are decided to be still, the

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area specifying unit 103 decides that the pixel of the frame #n being verified belongs to the uncovered background area.

Fig.34 shows an example of the area decision by the area specifying unit 103. In Fig.34A, a pixel decided to belong to the covered background area is shown in white. In Fig.34B, a pixel decided to belong to the uncovered background area is shown in white.

In Fig.34C, a pixel decided to belong to the moving area is shown in white. In Fig.34D, a pixel decided to belong to the still area is shown in white.

Fig.35 shows the area information representing the mixed area, among the area information output by the decision flag storage frame memory 126, as picture. In Fig.35, the pixel decided to belong to the covered background area or the uncovered background area, that is to the mixed area, is shown in white. The area information indicating the mixed area, output by the decision flag storage frame memory 126, indicates a textured portion surrounded by an untextured portion in the foreground area and the mixed area.

Referring to the flowchart of Fig.36, the processing for area identification by the area specifying unit 103 is explained. At step S121, the frame memory 121 acquires pictures of the frame #n·2 to frame #n+2, inclusive the frame #n.

At step S122, the still/moving discriminating unit 122-3 checks whether or not the pixels at the same position of the frame #n·1 and the frame #n are still. If the pixels are decided to be still, the program moves to step S123 where the still/moving

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discriminating unit 122-2 checks whether or not the pixels at the same position of the frame #n and the frame #n+1 are still.

If, at step S123, the pixels at the same position of the frame #n and the pixel of the frame #n+1 are decided to be still, the program moves to step S124 where the area decision unit 123-2 sets "1" in the still area decision flag corresponding to the pixel of the area being verified for indicating that the pixel belongs to the still area. The area decision unit 123-2 sends the still area decision flag to the decision flag storage memory 124. The program then moves to step S125.

If at step S122 the pixels at the same position of the frame #n·1 and the frame #n are decided to be moving or if at step S123 the pixels at the same position of the frame #n and the frame #n+1 are decided to be moving, the pixel of the frame #n does not belong to the still area, so the processing at stepS124 is skipped and the program moves to step S125.

At step S125, the still/moving discriminating unit 122-3 checks whether or not the pixels at the same position of the frame #n·1 and the frame #n are moving. If the pixels are decided to be moving, the program moves to step S126 where the still/moving discriminating unit 122-2 decides whether or not the pixels at the same position of the frame #n and the frame #n+1 are moving.

If, at step S126, the pixels at the same position of the frame #n and the pixel of the frame #n+1 are decided to be moving, the program moves to step S127 where the area decision unit 123-2 sets "1" in the movung area decision flag corresponding to the

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pixel of the area being verified for indicating that the pixel belongs to the moving area. The area decision unit 123-2 sends the moving area decision flag to the decision flag storage memory 124. The program then moves to step S128.

If at step S125 the pixels at the same position of the frame #n·1 and the frame #n are decided to be still or if at step S126 the pixels at the same position of the frame #n and the frame #n+1 are decided to be still, the pixel of the frame #n does not belong to the moving area, so the processing at stepS127 is skipped and the program moves to step S128.

At step S128, the still/moving discriminating unit 122-4 checks whether or not the pixels at the same position of the frame #n·2 and the frame #n·1 are still. If the pixels are decided to be still, the program moves to step S129 where the still/moving discriminating unit 122-3 decides whether or not the pixels at the same position of the frame #n·1 and the frame #n are moving.

If, at step S129, the pixels at the same position of the frame #n·1 and the pixel of the frame #n are decided to be moving, the program moves to step S130 where the area decision unit 123-3 sets "1" in the covered background area decision flag corresponding to the pixel of the area being verified for indicating that the pixel belongs to the covered background area. The area decision unit 123-3 sends the covered background area decision flag to the decision flag storage memory 124. The program then moves to step S131.

If at step S128 the pixels at the same position of the frame #n·2 and the frame

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#n·2 are decided to be moving or if at step S129 the pixels at the same position of the frame #n·1 and the frame #n are decided to be still, the pixel of the frame #n does not belong to the covered background area, so the processing at stepS130 is skipped and the program moves to step S131.

At step S131, the still/moving discriminating unit 122-2 checks whether or not the pixels at the same position of the frame #n and the frame #n+1 are still. If the pixels are decided to be moving, the program moves to step S132 where the still/moving discriminating unit 122-1 decides whether or not the pixels at the same position of the frame #n+1 and the frame #n+2 are moving.

If, at step S132, the pixels at the same position of the frame #n+1 and the pixel of the frame #n+2 are decided to be still, the program moves to step S133 where the area decision unit 123-1 sets "1" in the uncovered background area decision flag corresponding to the pixel of the area being verified for indicating that the pixel belongs to the uncovered background area. The area decision unit 123-1 sends the uncovered background area decision flag to the decision flag storage memory 124. The program then moves to step S134.

If at step S131 the pixels at the same position of the frame #n and the frame #n+1 are decided to be still or if at step S132 the pixels at the same position of the frame #n+1 and the frame #n+2 are decided to be moving, the pixel of the frame #n does not belong to the uncovered background area, so the processing at stepS133 is skipped and the program moves to step S134.

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At step S134, the area specifying unit 103 checks whether or not the area has been specified for the totality of the pixels of the frame #n. If it is decided that the area has not been specified for the totality of the pixels of the frame #n, the program reverts to step S122 to repeat the area specifying processing for the remaining pixels.

If it is decided at step S134 that the area has been specified for the totality of the pixels of the frame #n, the program moves to step S135 where the synthesis unit 125 generates the area information indicating the mixed area based on the uncovered background area decision flag and the covered background area decision flag, stored in the decision flag storage memory 124, while also generating the area information indicating to which of the uncovered background area, still area, moving area and the uncovered background area belongs each pixel. The synthesis unit 125 sets the generated area information in the decision flag storage frame memory 126 to finish the processing.

In this manner, the area specifying unit 103 is able to generate the area information, for each of pixels comprehended in a frame, indicating that the pixel in question belongs to the movement area, still area, covered background area or to the uncovered background area.

It is also possible for the area specifying unit 103 to apply logical sum to area information corresponding to the uncovered background area and the covered background area to generate the area information comprising a flag indicating that a given pixel contained in the frame belongs to the movement area, still area or to the

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mixed area, for each pixel contained in the frame.

If the object associated with the foreground includes a texture, the area specifying unit 103 is able to specify the movement area more accurately.

The area specifying unit 103 is able to output the area information indicating the movement area as the area information indicating the foreground area, or the area information indicating the still area as the area information indicating the background area.

In the foregoing, it is assumed that the object corresponding to the background is still. However, the above-described area specifying processing can be applied even if the picture associated with the background area contains motion. For example, if the picture corresponding to the background area is moving uniformly, the area specifying unit 103 shifts the entire picture in association with the movement to perform the processing in the same way as when the object corresponding to the background is still. If the picture associated with the background area contains different movements from one location to another, the area specifying unit 103 selects the pixels corresponding to the movement to perform the above processing.

Fig.37 shows a block diagram showing an illustrative structure of the mixing ratio calculating unit 104. The estimated mixing ratio processor 201 calculates the estimated mixing ratio, from one pixel to another, by calculations corresponding to the model of the covered background area, based on the input picture, to route the calculated estimated mixing ratio to a mixing ratio decision unit 203.

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An estimated mixing ratio processing unit 202 calculates the estimated mixing ratio, from pixel to pixel, by calculations corresponding to the model of the uncovered background area, based on the input picture, to route the calculated mixing ratio to the mixing ratio decision unit 203.

Since the object corresponding to the foreground may be assumed to be moving at an equal speed within the shutter time, the mixing ratio α of a pixel belonging to the mixed area has the following properties: That is, the mixing ratio α is changed linearly relative to changes in the pixel positions. If the changes of the pixel positions are one-dimensional, the changes in the mixing ratio α can be represented as a plane.

Since the one-frame period is short, it may be assumed that the object corresponding to the foreground is a rigid member and is moving at an equal speed.

Meanwhile, the tilt of the mixing ratio α is inversely proportionate to the movement quantity v of the foreground within the shutter time.

Fig.38 shows an example of an ideal mixing ratio α. The tilt 1 in the mixing area with an ideal mixing ratio α can be represented as a reciprocal of the movement quantity v.

In the embodiment of Fig.39, the pixel value C06 of the seventh pixel from left of the frame #n can be represented, using the pixel value P06 of the seventh pixel from left of the frame #n·1, by the equation (14):

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$$C06 = B06/v + B06/v + F01/v + F02/v$$
$$= P06/v + P06/v + F01/v + F02/v$$
$$= 2/v \cdot P06 + \sum_{i=1}^{2} F_i/v$$

$$\cdots (14)$$

In the equation (14), the pixel value C06 is expressed as a pixel value M of the pixel of the mixed area, whilst the pixel value P06 is expressed as a pixel value B of the pixel of the background area. That is, the pixel value M of the mixed area and the pixel value B of the background may be represented by the equations (15) and (16), respectively:

$$M = C06$$

$$\cdots (15)$$

$$C = \alpha \cdot P + f$$

$$\cdots (16).$$

In the equation (14), 2/v corresponds to the mixing ratio α. Since the movement quantity v is 4, the mixing ratio α of the seventh pixel from left of the frame #n is 0.5.

By assuming that the pixel value C of the frame #n under consideration and the pixel value P of the frame #n·1 directly previous to the frame #n as being the pixel value of the mixed area and the pixel value of the background, respectively, the equation (13) indicating the mixing ratio α can be rewritten to the following equation (17):

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$$C = \alpha \cdot P + f$$

$$\cdots (17)$$

where f denotes the sum $\Sigma_i F_i/v$ of the foreground components contained in the considered pixel. There are two variables in the equation (17), namely the mixing ratio α and the sum f of the foreground components.

Fig.40 shows a model in which the movement quantity v in the uncovered background area is 4 and the number of times of the virtual splitting along the time axis is 4, with the pixels being shown developed along the time axis direction.

By assuming, in the uncovered background area, that the pixel value C of the frame #n under consideration and the pixel value P of the frame #n+1 next to the frame #n as being the pixel value of the mixed area and the pixel value of the background, respectively, as in the covered background area, discussed above, the equation (13) indicating the mixing ratio α can be represented as in the following equation (18):

$$C = \alpha \cdot N + f$$

$$\cdots (18).$$

Although the background object is assumed to be still in the foregoing description, the equations (14) to (18) may be applied by exploiting the pixel values of the pixels associated with the background movement quantity v even if the background object is moving. For example, if, when the movement quantity v of the object corresponding to the background is 2 and the number of times of the virtual

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splitting is 2, the object corresponding to the background is moving towards right in the drawing, the pixel value B of the pixel of the background area in the equation (16) is the pixel value P04.

Since the equation (17) and (18) each contain two variables, the mixing area α cannot be found directly. It should be noted that, since the picture in general exhibits strong spatial correlation, the pixels proximate to each other are of approximately the same pixel values.

Since the foreground components exhibits strong spatial correlation, the equation is modified so that the mixing area α by the sum of the foreground components will be derived from the previous frame or the subsequent frames.

The pixel value Mc of the seventh pixel from left of the frame #n of Fig.41 can be represented by the following equation (19):

$$M_c = \frac{2}{v} \cdot B06 + \sum_{i=11}^{12} Fi / v \qquad \cdots (19)$$

where 2/v of the first term of the right side corresponds to the mixing ratio α. By exploiting the pixel value of the subsequent frame #n+1, the second term of the right side of the equation (19) may be represented by the equation (20):

$$\sum_{i=11}^{12} Fi / v = \beta \cdot \sum_{i=7}^{110} Fi / v \qquad \cdots (20).$$

It is here assumed, by exploiting the spatial correlation of the foreground components, the following equation (21) holds:

$F = F05 = F06 = F07 = F08 = F09 = F10 = F11 = F12$

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$$\cdots (21)$$

which may be used to rewrite the equation (20) to

$$\sum_{i=11}^{12} Fi / v = \frac{2}{v} \cdot F$$
$$= \beta \cdot \frac{4}{v} \cdot F$$

$$\cdots (22).$$

As a result, β can be represented by the following equation (23)

$$\beta = 22/4$$

$$\cdots (23).$$

In general, if it is assumed that the foreground components relevant to the mixed area are equal, as shown by the equation (21), the following equation (24):

$$\beta = 1 \cdot \alpha$$

$$\cdots (24)$$

holds, by the ratio of the internal division, for the totality of pixels of the mixed area.

If the equation (24) holds, the equation (17) can be expanded as in the equation (25):

$$C = \alpha \cdot P + f$$
$$= \alpha \cdot P + (1 - \alpha) \cdot \sum_{i=\gamma}^{\gamma + V - 1} Fi / v$$

$$\cdots (25).$$

$$= \alpha \cdot P + (1 - \alpha) \cdot N$$

Similarly, if the equation (24) holds, the equation (18) can be expanded as in the equation (26):

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$$C = \alpha \cdot N + f$$
$$= \alpha \cdot N + (1-\alpha) \cdot \sum_{i=\gamma}^{\gamma+\nu-1} Fi/v$$
$$= \alpha \cdot N + (1-\alpha) \cdot P$$

$$\cdots (26).$$

In the equations (25) and (26), since C, N and P are known pixel values, the there is only one variable contained in the equations (25) and (26), that is the mixing ratio α. The relation among C, N and P in the equations (25) and (26) is shown in Fig.42. It is noted that C, N and P are a pixel value of a pixel of the frame #n under consideration, a pixel value of a pixel of the frame #n+1, the position of which in the spatial direction is in register with that of the considered pixel, and a pixel value of the pixel of the frame #n+1, the position of which in the spatial direction is in register with that of the considered pixel, respectively.

Thus, each one variable is contained in each of the equations (25) and (26), so the mixing ratio α can be calculated by exploiting the pixel values of the pixels of the three frames. The condition for the correct mixing ratio α to be calculated by solving the equations (25) and (26) is that the foreground components relevant to the mixed area are equal, that is that the pixel values of a number of the consecutive pixels twice the movement quantity x, which pixels are in the picture object of the foreground imaged in a standstill state, and which are positioned at a boundary of the picture object in association with the moving direction of the foreground are constant.

The mixing ratio α of the pixels belonging to the covered background area is calculated by the equation (27), whilst the mixing ratio α of the pixel belonging to the

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uncovered background area is calculated by the following equations (27) and (28):

$$\alpha = (C \cdot N)/(P \cdot N)$$

$$\cdots (27)$$

$$\alpha = (C \cdot P)/(N \cdot P)$$

$$\cdots (28).$$

In Fig.43, which is a block diagram showing the structure of the estimated mixing ratio processor 201, a frame memory 221 stores the input pictures on the frame basis, and feeds a frame, next to the frame being input as an input picture, to a frame memory 222 and to a mixing ratio calculating unit 223.

The frame memory 222 stores the input pictures on the frame basis and routes a frame next following the frame being supplied from the frame memory 221 to the mixing ratio calculating unit 223.

So, if the frame #n+1 is being input as an input picture to the mixing ratio calculating unit 223, the frame memory 221 routes the frame #n to the mixing ratio calculating unit 223, whilst the frame memory 222 routes the frame #n·1 to the mixing ratio calculating unit 223.

The mixing ratio calculating unit 223 calculates an estimated mixing ratio of the considered pixel, by calculations of the equation (27) on the pixel value C of the pixel of the frame #n under consideration, the pixel value of the pixel of the frame #n+1, the spatial position of which is in registration with that of the considered pixel, and the pixel value of the pixel of the frame #n·1, the spatial position of which is in

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registration with that of the considered pixel, and outputs the so-calculated estimated mixing ratio. For example, if the background is at a standstill, the mixing ratio calculating unit 223 calculates the estimated mixing ratio of the considered pixel, from the pixel value C of the pixel of the frame #n under consideration, the pixel value N of the pixel of the frame #n+1, the position of which in the frame is the same as that of the considered pixel, and the pixel value P of the pixel of the frame #n·1, the position of which in the frame is the same as that of the considered pixel, and outputs the so-calculated estimated mixing ratio.

In this manner, the estimated mixing ratio processor 201 calculates the estimated mixing ratio, based on the input picture, to route the so-calculated estimated mixing ratio to the mixing ratio decision unit 203.

The estimated mixing ratio processor 202 is similar to the estimated mixing ratio processor 201 except that the estimated mixing ratio processor 201 calculates the estimated mixing ratio of the considered pixel in accordance with the equation (27), whilst the estimated mixing ratio processor 202 calculates the estimated mixing ratio of the considered pixel in accordance with the equation (28), and hence the corresponding description is omitted for clarity.

Fig.44 shows an example of the estimated mixing ratio calculated by the estimated mixing ratio processor 201. Fig.44 shows the estimated mixing ratio for the movement quantity v of the foreground corresponding to an object moving at a constant speed equal to 11 for one line.

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It is seen that the estimated mixing ratio is changing in the mixed area substantially linearly as shown in Fig.38.

Reverting to Fig.37, the mixing ratio decision unit 203 sets the mixing ratio α based on the area information from the area specifying unit 103 indicating to which of the foreground area, background area, covered background area and the uncovered background area belongs the pixel supplied from the area specifying unit 103 as basis for calculation of the mixing ratio α. The mixing ratio decision unit 203 sets 0 or 1 as the mixing ratio if the pixel as a basis for calculation belongs to the foreground area or to the background area, respectively. On the other hand, the mixing ratio decision unit 203 sets the estimated mixing ratio supplied from the estimated mixing ratio processor 201 as the mixing ratio α if the pixel as a basis for calculation belongs to the covered background area, while setting the estimated mixing ratio supplied from the estimated mixing ratio processor 202 as the mixing ratio α if the pixel as a basis for calculation belongs to the uncovered background area. The e203 outputs the mixing ratio α as set based on the area information.

In Fig.45, which is a block diagram showing an alternative structure of the mixing ratio calculating unit 104, a selection unit 231 routes the pixel belonging to the covered background area and pixels of the associated previous and subsequent frames to an estimated mixing ratio processor 232, based on the area information supplied from the area specifying unit 103. The selection unit 231 routes the pixels belonging to the uncovered background area and pixels of the associated previous and

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subsequent frames to an estimated mixing ratio processor 233, based on the area information supplied from the area specifying unit 103.

The estimated mixing ratio processor 232 calculates the estimated mixing ratio of the considered pixel belonging to the covered background area, by calculations in accordance with the equation (27), based on the pixel values input from the selection unit 231, to route the so-calculated estimated mixing ratio to a selection unit 234.

The estimated mixing ratio processor 233 calculates the estimated mixing ratio of the considered pixel belonging to the uncovered background area, by calculations in accordance with the equation (28), based on the pixel values input from the selection unit 231, to route the so-calculated estimated mixing ratio to a selection unit 234.

The selection unit 234 sets the mixing ratio α based on the area information from the area specifying unit 103 indicating to which of the foreground area, background area, covered background area and the uncovered background area belongs the pixel supplied from the area specifying unit 103 as basis for calculation of the mixing ratio α. The mixing ratio decision unit 203 sets 0 or 1 as the mixing ratio if the pixel as a basis for calculation belongs to the foreground area or to the background area, respectively. On the other hand, the selection unit 234 sets the estimated mixing ratio supplied from the estimated mixing ratio processor 232 as the mixing ratio α if the pixel as a basis for calculation belongs to the covered background area, while setting the estimated mixing ratio supplied from the estimated mixing ratio

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processor 233 as the mixing ratio α if the pixel as a basis for calculation belongs to the uncovered background area. The selection unit 234 outputs the mixing ratio α selected and set based on the area information.

The mixing ratio calculating unit 104, having a modified structure shown in Fig.45, calculates the mixing ratio α, from one pixel of the picture to another, to output the calculated mixing ratio α.

Referring to the flowchart of Fig.46, the processing for calculating the mixing ratio α of the mixing ratio calculating unit 104, the configuration of which is shown in Fig.37, is explained. At step S151, the mixing ratio calculating unit 104 acquires the area information supplied from the area specifying unit 103. At step S151, the mixing ratio calculating unit 104 acquires the area information supplied from the area specifying unit 103. At step S152, the estimated mixing ratio processor 201 calculates the estimated mixing ratio by a model corresponding to the covered background area to route the so-calculated estimated mixing ratio to the mixing ratio decision unit 203. The processing for calculating the estimated mixing ratio will be explained subsequently in detail by referring to flowchart of Fig.47.

At step S153, the estimated mixing ratio processor 202 calculates the estimated mixing ratio by a model corresponding to the covered background area to route the so-calculated estimated mixing ratio to the mixing ratio decision unit 203.

At step S154, the mixing ratio calculating unit 104 checks whether or not the mixing ratio α has been estimated for the entire frame. If it is found that the mixing

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ratio α has not been estimated for the entire frame, the program reverts to step S152 to execute the processing of estimating the mixing ratio α for the next pixel.

If it is decided at step S154 that the mixing ratio α has been estimated for the entire frame, the program reverts to step S155 where the mixing ratio decision unit 203 sets the mixing ratio α based on the area information supplied from the area specifying unit 103 and which indicates to which of the foreground area, background area, covered background area or the uncovered background area belongs the pixel. The mixing ratio decision unit 203 sets 0 or 1 as the mixing ratio if the pixel as a basis for calculation belongs to the foreground area or to the background area, respectively. On the other hand, the mixing ratio decision unit 203 sets the estimated mixing ratio supplied from the estimated mixing ratio processor 201 as the mixing ratio α if the pixel as a basis for calculation belongs to the covered background area, while setting the estimated mixing ratio supplied from the estimated mixing ratio processor 202 as the mixing ratio α if the pixel as a basis for calculation belongs to the uncovered background area. The processing then is finished.

In this manner, the mixing ratio calculating unit 104 is able to calculate the mixing ratio α, as a characteristic value for each pixel, based on the area information supplied from the area specifying unit 103 and on the input picture.

The processing for calculating the mixing ratio α by the mixing ratio calculating unit 104 shown in Fig.45 is similar to that explained by referring to the flowchart of Fig.46 and hence is not explained specifically.

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Referring to the flowchart of Fig.47, the processing similar to step S152 of Fig.46 for estimating the mixing ratio by a model corresponding to the covered background area is explained.

At step S171, the mixing ratio calculating unit 223 acquires the pixel value C of the considered pixel of the frame #n from the frame memory 221.

At step S172, the mixing ratio calculating unit 223 acquires the pixel value C of the considered pixel of the frame #n·1 from the frame memory 222.

At step S173, the mixing ratio calculating unit 223 acquires the pixel value N of the frame #n+1, corresponding to the considered pixel contained in the input picture.

At step S174, the mixing ratio calculating unit 223 calculates the estimated mixing ratio based on the pixel value C of the considered pixel of the frame #n, pixel value P of the pixel of the frame #n·1 and on the pixel value N of the pixel of the frame #n+1.

At step S175, the mixing ratio calculating unit 223 checks whether or not the processing for calculating the estimated mixing ratio has been finished for the entire frame. If it is decided that the processing for calculating the estimated mixing ratio has not been finished for the entire frame, the program reverts to step S171 to repeat the processing of calculating the estimated mixing ratio for the next pixel.

If it is verified at step S175 that the processing for calculating the estimated mixing ratio has been finished for the entire frame, the processing is finished.

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In this manner, the estimated mixing ratio processor 201 is able to calculate the estimated mixing ratio based on the input picture.

The processing for estimating the mixing ratio by the model corresponding to the uncovered background area at step S153 of Fig.46 is similar to the processing exploiting the equation corresponding to the model of the uncovered background area, as shown in the flowchart of Fig.47, and hence is not explained specifically.

Meanwhile, since the estimated mixing ratio processor 232 and the estimated mixing ratio processor 233, shown in Fig.45, calculates the estimated mixing ratio by executing the processing similar to the processing of the flowchart of Fig.47, the corresponding operation is omitted for simplicity.

In the foregoing explanation, it is assumed that the object corresponding to the background is at a standstill. However, the processing for finding the mixing ratio α can also be applied to a case in which a picture corresponding to the background contains the movement. For example, if a picture corresponding to the background area is moving uniformly, the estimated mixing ratio processor 201 shifts the entire picture in keeping with the movement of the background to perform the processing as if the object corresponding to the background is at a standstill. On the other hand, if the picture corresponding to the background area contains movements of the background which differ from one location to another, the estimated mixing ratio processor 201 selects the pixel associated with the background movement, as the pixel corresponding to the pixel belonging to the mixed area, to execute the above-described

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processing.

The structure of the mixing ratio calculating unit 104 shown in Figs.37 or 45 is merely illustrative.

It is also possible for the mixing ratio calculating unit 104 to execute only the processing for estimating the mixing ratio by the model corresponding to the covered background area to output the so-calculated estimated mixing ratio as the mixing ratio α. In this case, the mixing ratio α indicates the proportion of the foreground and the background for a pixel belonging to the covered background area and for a pixel belonging to the uncovered background area, respectively. If the absolute value of the difference between the so-calculated mixing ratio α and 1 is calculated to set the so-calculated absolute value as the mixing ratio α, the signal processor 12 is able to find the mixing ratio α indicating the proportion of the background component for the pixel belonging to the uncovered background area.

It is also possible to execute only the processing for mixing ratio estimation by a model corresponding to the uncovered background area for the totality of the pixels to output the so-calculated estimated mixing ratio as the mixing ratio α.

The foreground/background separating unit 105 is now explained. In Fig.48 which is a block diagram showing the illustrative structure of the foreground/background separating unit 105, an input picture, fed to the foreground/background separating unit 105, is supplied to a separating unit 251, a switch 252 and to a switch 254. The area information from the area specifying unit